ARMY RESEARCH LABORATORY

Demonstration/Validation of Low Volatile Organic Compound (VOC) Chemical Agent Resistant Coating (CARC) at Tobyhanna Army Depot

by Jeffrey L. Duncan and John A. Escarsega

ARL-TR-2986

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Weapons and Materials Research Directorate, ARL

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14. ABSTRACT
As part of a tri-Service effort funded by the Environmental Security Technology Demonstration Program (ESTCP), the U.S. Army Research Laboratory (ARL)-patented water-dispersible (WD) chemical agent resistant coating (CARC) has undergone technology demonstration/validation (dem/val) testing at U.S. Department of Defense depot facilities in order to verify its performance when applied in a production environment. The tri-Service team members include ARL; the Naval Surface Warfare Center, Carderock Division representing the Marine Corps; and the Air Force Research Laboratory. Demonstrations were held at three depot facilities, one for each of the Services, including Barstow Marine Corps Logistics Base, Ogden Air Logistics Center, and Tobyhanna Army Depot. This ESTCP effort was transitioned from a similar Strategic Environmental Research and Development Program project that consisted of the same team members and was at the laboratory-scale research level. It verified that the WD CARC is essentially a "drop-in" substitute for the current solvent-based CARC because it could be applied and stripped using existing equipment and processes at the depot facilities. This report summarizes the application dem/val held at the Army demonstration site, Tobyhanna Army Depot, during the period of 30 October–1 November 2000.

15. SUBJECT TERMS
CARC, low VOC, ESTCP, demonstration, validation, WD CARC, MIL-DTL-64159

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Contents

List of Figures

List of Tables

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1. Background

Chemical warfare survivability is mandated by U.S. Army Regulation (AR) 750-1 (*1*), which the U.S. Marine Corps also follows. This means that all tactical equipment (including combat, combat support, essential ground support equipment, tactical wheeled vehicles, and aircraft) must be hardened against performance degradation caused by chemical warfare agents or decontamination procedures. Therefore, virtually everything in the U.S. Army and U.S. Marine Corps inventory, plus U.S. Air Force vehicles and equipment procured through the U.S. Army, is painted with a chemical agent resistant coating (CARC) meeting one of two military specifications: MIL-C-46168 (*2*) or MIL-C-53039 (*3*). However, Federal and local regulations resulting from the "Clean Air Act" (*4*) and its amendments have resulted in restrictions on the volatile organic compound (VOC) content contained in and emitted during the application of protective coatings. The previously mentioned topcoats have Federal VOC limits set at 3.5 lb/gal, but local governments are permitted to set lower limits, and many, such as the San Diego Air Quality Management District (which has a limit of 2.8 lb/gal), have done so. In addition, total emission restrictions imposed on some facilities are such that a limit of 1.8 lb/gal must be achieved for the facility to stay in production. Finally, many of the solvents are hazardous air pollutants (HAPs) either as listed by the Clean Air Act Amendments of 1990 or targeted by the Environmental Protection Agency (EPA) 33/50 Industrial Toxics Project (*5*).

When the U.S. Army first used the CARC system on tactical equipment in the early 1980s, it was in compliance with environmental regulations in effect at that time. However, Federal and local regulations have since resulted in further restrictions in the amount of VOCs and HAPs that can be emitted during the application and curing of protective coatings. The current approach to the problem is either to incur the high cost of procuring, installing, and maintaining an emission control system or to deviate from the CARC requirement and utilize a coating that meets environmental regulations but does not provide chemical agent resistance. The former approach can be economically prohibitive, and the latter approach results in a severe compromise to mission readiness.

The technology to be demonstrated/validated (dem/val) was developed primarily under the Strategic Environmental Research and Development Program (SERDP) Project PP #1056 (*6*), which was initiated in FY97 and was funded by SERDP through FY99. The tri-Service team members included ARL; the Naval Surface Warfare Center, Carderock Division (NSWCCD) representing the U.S. Marine Corps; and the Air Force Research Laboratory (AFRL). Responsibilities in the effort were divided as follows: the U.S. Army was the lead organization and was responsible for the research and development portion of the program, the U.S. Navy was responsible for the application part, and the U.S. Air Force was responsible for the stripping aspects. Using recent developments in polymer and pigmentation technology, ARL was successful in developing a high-performance water reducible, water dispersible (WD) CARC polyurethane topcoat. The formulation developed under the SERDP project succeeded in meeting the VOC objective of 1.8 lb/gal and has eliminated HAPs as well. In addition to being fully environmentally compliant, the new coating shows significant performance enhancements, as evidenced by improvements in low-temperature flexibility, mar resistance, and weathering durability. A U.S. Patent has been awarded for the WD formula that was the basis of the SERDP effort (*7*).

Currently used CARC coating formulations contain 3.5 lb/gal of VOCs. The current annual usage nationwide is estimated to be 3.0 million gal/year. A CARC targeted to a 1.8 lb/gal VOC limit would save at least 5 million lb of VOC/year in the application of the coating, proportionately reduce photochemical smog generation, and avert Notices of Violation at user facilities including depots, air logistic centers (ALCs), military bases, and original equipment manufacturers. Those VOCs that would be eliminated include methyl isobutyl ketone, methyl isoamyl ketone, toluene, xylene, and butyl acetate, most of which are HAPs. Furthermore, the technology developed by this project will eliminate the need to install emission control devices such as carbon absorption and/or incineration units to bring facilities into VOC compliance. This will result in a cost avoidance at a typical ALC or depot of $5 million for equipment and installation and an annual operating cost avoidance of $250,000. Since there are ~10 such facilities that would require pollution controls if low VOC formulations were not developed, the total cost avoidance would be $50 million for equipment and installation and $2.5 million saved in annual operating costs.

By developing one CARC topcoat for use by all the Services, substantial savings will result in procurement and logistics operations. A single CARC formulation will result in procuring larger quantities than would otherwise be possible, with increased competition tending to drive the price down. Planning, transportation, and storage will be simplified by having one coating for all Services that will also result in reducing costs of these operations. Since the WD CARC is a superior product (enhanced mar resistance, flexibility, and weathering durability) compared to current CARC, it is expected that its service life will greatly exceed that of the current material and will therefore not require stripping and repainting as often.

The same tri-Service team previously mentioned was funded by the Environmental Security Technology Certification Program (ESTCP) for FY00 through FY02 to dem/val the WD CARC technology developed in the laboratory-scale SERDP effort to assist in transitioning it to the field. The method chosen was to select three depot facilities, one for each of the participating Services, and verify its performance when applied to military equipment in a production environment, using a full-scale production batch prepared by an industrial coating manufacturer. During the application demonstration, test panels would be prepared to be used in later studies of coating removal at the same depot facilities. The following facilities and dates were selected for the ESTCP dem/val effort:

- U.S. Marine Corps: Barstow Marine Corps Logistics Base, Barstow, CA, 9–11 May 2000;
- U.S. Air Force: Ogden Air Logistics Center, Ogden, UT, 28–30 August 2000;
- U.S. Army: Tobyhanna Army Depot (TYAD), Tobyhanna, PA, 30 October–2 November 2000.

The U.S. Army demonstration site, TYAD, is the largest full-service communications-electronics maintenance facility in the Department of Defense with over 3000 employees. The depot's mission includes the design, manufacture, repair, overhaul, and fabrication of hundreds of communications and electronics systems. Communications-electronics (C-E) systems supported by Tobyhanna include communications, command and control, surveillance and target acquisition, airborne electronics intelligence and electronic warfare, electronic support equipment, and power systems. TYAD is a leader in the areas of automatic test equipment, systems integration, and the downsizing of military C-E systems. Its capabilities can be summarized as follows:

C-E Source of Repair (SOR):

- Communication systems,
- Command and control systems,
- Surveillance and target acquisition systems,
- Avionics systems,
- Intelligence and electronic warfare systems,
- Automatic data processing systems power systems, and
- Electronic support equipment and systems.

Worldwide Technical Assistance:

- Field service support,
- Customer assistance hotline, and
- Forward repair activities.

Special Missions:

- Satellite communications (SATCOM) support, and
- Communications security (COMSEC) support.

Fabrication Support:

- Flexible computer integrated manufacturing (FCIM),
- Nondevelopment item (NDI)/commercial off-the-shelf (COTS) equipment ruggedizing and hardening,
- C-E systems downsizing and prototyping,
- Installation kits,
- Circuit card assemblies,
- Equipment rack systems,
- Switch/junction boxes distribution boxes/panels,
- Mobile equipment power plants,
- Power units/generators, and
- Textile goods fabrication.

Engineering and Technical Support:

- Electronics design,
- Mechanical design,
- Technical data package (TDP) development,
- Configuration management,
- Project management,
- Engineering support,
- Test program set (TPS) support,
- Test development laboratory,
- Integrated logistics support,
- Technical publications support,
- Product assurance,
- Safety engineering, and
- Human engineering.

2. Test Procedures

Since the object of the dem/val was to demonstrate the "drop-in" nature of the WD CARC, several pieces of defense equipment were selected to be painted along with a matrix of test panels necessary to characterize the applied coating and verify the acceptability of its performance. Prior to the actual dem/val, a site visit was made on 13 September 2000, at which the program background and goals were presented to TYAD personnel, along with proposed procedures to be used at the demonstration. The contents of that briefing are in Appendix A. The ESTCP team provided TYAD personnel with background information about the coating, focused on the SERDP efforts, application, anticipated performance, stripping considerations, safety and environmental issues, availability, and implementation plans. The application process was to be conducted in accordance with standard U.S. Army procedures and health and safety guidelines. TYAD agreed to provide 3–5 production-type items for the demonstration. Subsequently, a formal memorandum (Appendix B) was submitted to TYAD management. The actual dem/val was held during the period 30 October–1 November 2000.

Prior to the arrival of the ESTCP team members, TYAD personnel had selected several pieces of equipment and components typical of their production. This included Gichner Mobile Systems (GMS)-250 shelters, 9000-Btu air conditioning (AC) units, 5T fuel trailer legs, a 3199 antenna pedestal base, and AN/TRC-170 antenna trailer components. All had been prepared for final topcoat application on reworked equipment. This included, as appropriate, media blasting to remove corrosion, pretreatment with wash primer in accordance with DOD-P-15328 (*8*), and application of anticorrosive primer MIL-P-53030A (*9*), manufactured by Deft Chemical Coatings.

Aluminum and steel test panels were provided by each Service for concurrent application of the WD CARC system. These panels were used for laboratory testing by each agency involved in the project. The panels provided by NSWCCD were used for various tests to characterize the coating. These tests include the following: adhesion, specular gloss, color difference, viscosity, and Taber abrasion. The results are provided in this report. The panels provided by the Army were used for color, gloss, Decontaminating Solution No. 2 (DS2) resistance, chemical agent resistance, and accelerated weathering. The Air Force panels were exposed to accelerated weathering for 10 months prior to being used in the ESTCP stripping study scheduled for November 2001 at TYAD. The steel panels provided by NSWCCD had a zinc phosphate pretreatment (TT-C-490 (*10*) type I) as prepared by Metal Samples, Inc., Munford, AL. The aluminum panels had a chromic acid anodized pretreatment (MIL-A-8625 (*11*) type I) as applied by All Steel Fabricators Co., Inc., Bala Cynwyd, PA. The steel panels provided by the Army also had the same type of zinc phosphate pretreatment, which was applied by the manufacturer, ACT Laboratories, Inc., Hillsdale, MI. The Air Force provided both steel and aluminum panels.

The steel panels were pretreated with zinc phosphate by Metal Samples, Inc., and the aluminum panels were provided with a chromate conversion pretreatment per MIL-C-5541 (*12*), class 1A.

The MIL-P-53030 epoxy primer, manufactured by Deft Chemical Coatings Co., was applied to the test panels on 30 October 2000, in the small parts area of Building 1A. The ESTCP team members were present during the application. The panels were laid out horizontally on a table, and the primer was applied with a Graco Delta 2000 high-volume, low-pressure (HVLP) siphon feed cup gun. No runs, sags, or other defects were noted. The panels were allowed to dry overnight before they were moved to Building 9, where the WD CARC application was performed.

The mixing and application of the WD CARC topcoat began at ~0900 on 31 October 2000. It was manufactured by the Sherwin-Williams (S-W) Company. Component A, the pigmented polyol base, was product no. F93G502, S-W internal sales no. 6016-24133, lot no. 0X2090, manufactured in Wichita, KS in July 2000. The color was Green 383, matching color number 34094 of FED-STD-595 (*13*). The isocyanate catalyst was product no. V93V502, S-W internal sales no. 6016-18077, lot no. 0X2360, manufactured in Wichita, KS in August 2000. The mixing ratio of the coating is two parts by volume of component A to one part by volume of Component B. ARL and S-W recommend reduction of this admix with 0.75 volumes of deionized water for spray application. Two gal of component A were mechanically mixed on a paint shaker for ~10 min and poured into a mixing container. One gal of component B was added, and the admix was stirred for 3 min using a hydraulically powered squirrel cage mixer. Then, 0.75 gal of deionized water was added to the paint and mixed for 3 min using a hydraulically powered squirrel mixer. At the end of the mixing procedure, the viscosity was checked with a no. 3 Zahn cup for the proper application viscosity, between 13 and 18 s. The environmental conditions were noted (temperature and relative humidity) prior to application of the paint.

Before the TYAD painters began to paint the selected equipment, they practiced on various substrates in the spray booth to familiarize themselves with WD CARC application properties. In all cases, Graco Delta 2000 HVLP siphon feed cup guns were used. They then painted the primed test panels for subsequent performance testing. Between the hours of 1000 and 1500, the following components were painted:

- 3 small AC units (9000 Btu) each with dimensions of ~26 in (length) × 26 in (width) × 16 in (height),
- 1 large antenna pedestal base (no. 3199) (pyramidal frame shaped each leg ~4–5 ft),
- 1 small tripod (each leg ~3 ft long),
- 4 AN/TRC-170 antenna trailer components (~5 ft long, ~1-ft diameter),
- 4 legs to a 5-ton fuel trailer (~3 ft long, 12-ft base, 6-in-diameter shaft), and
- 2 GMS-250 shelters.

Although an occasional sag was observed, application went well. In general, atomization, leveling, and film formation were satisfactory. While the tendency of a paint to sag and/or run depends on the technique of the applicator in making adjustments to his equipment and on the design of the items being painted (i.e., recessed areas, sharp edges, raised rivets, etc.), the painters learned quickly how much wet coating to apply to provide the needed dry film thickness of ~2 mils without generating sags. At the end of the shift, ~1 gal was unused. Since 3.75 gal were prepared at the start of the day, 2.75 gal were consumed in painting the various components and test panels.

On 1 November 2000 at ~0845, another kit of the S-W WD CARC was prepared as previously described. The viscosity was checked with a no. 3 Zahn cup for proper application viscosity. The equipment painted was one GMS-280 shelter with approximate dimensions of 12 ft (length) $\times$ 6 ft (width) $\times$ 7 ft (height). As with the day before, the painters indicated that the coating applied well, and while a few sags were observed, upon most of the solvent flashing off, the film was uniform, with few defects. Photographs were taken at various stages of the coating application process (Figures 1–10).

Upon completion of the WD CARC application each day, the painters were asked to complete a WD CARC Field Trial Application Survey developed by NSWCCD. The survey contained questions about the mixing and spraying characteristics of the WD CARC as compared to the solvent-based MIL-C-53039 normally used at TYAD. In addition, it asked for an overall general opinion of the WD CARC as compared to the solvent-based CARC. The completed surveys from four painters are found in Appendix C. By assigning numbers to the qualitative assessments, it became possible to generate average ratings. The lowest number (1) reflected the much more difficult, much slower, and much worse rating, and the highest number (5) reflected the much easier, much quicker, and much better rating. The overall average opinion for the four painters indicted that the mixing of the WD CARC with regard to complexity, ease, and time required was slightly worse (rating ~2) than MIL-C-53039, the spray properties with regard to spray ease, spray quality, application rate, and applied film quality were better (rating ~4), and overall, the WD CARC was considered better (rating ~4). The mixing preference for MIL-C-53039 is likely due to the fact that it is a single component product not requiring the premixing of two components, nor reduction for spray application in most cases. Information about the WD CARC, including the technical data sheet, material safety data sheet (MSDS), and certification by a manufacturer's representative that the coating application process met their guidelines is contained in Appendix D.

3. Verification Testing: ARL

The verification tests performed by ARL were extracted from the list developed for the Project Technology Demonstration Plan. The list includes color, specular gloss, accelerated weathering, DS2 resistance, chemical agent resistance, Equatorial Mirror Mount with water (EMMAQUA)

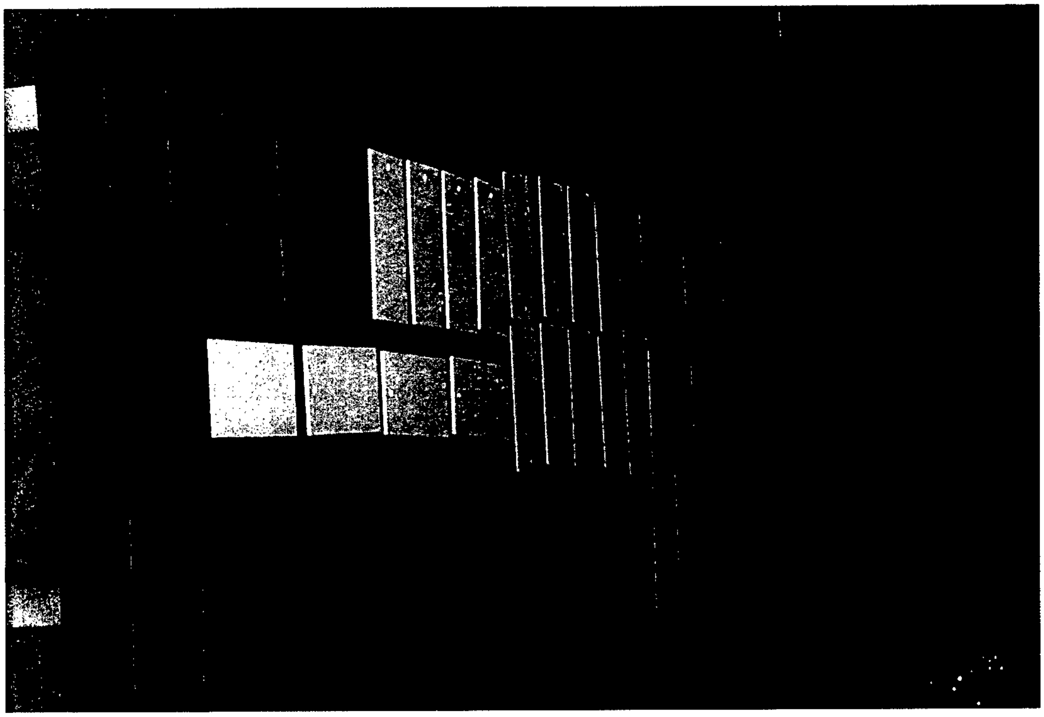

Figure 1. Test panels before application of WD CARC.

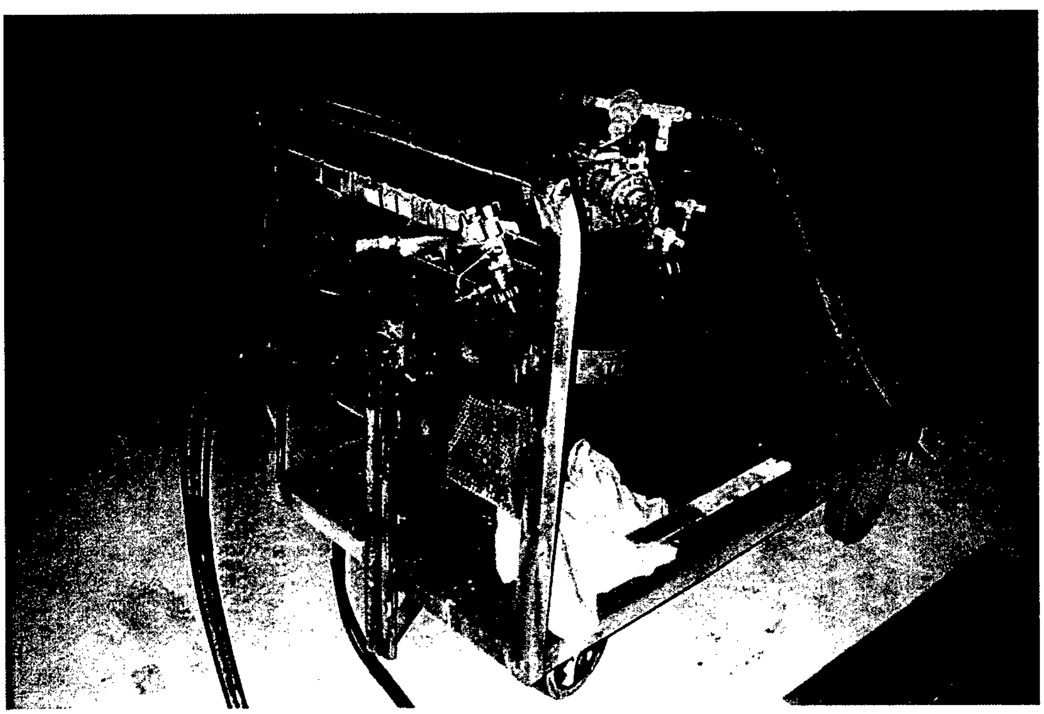

Figure 2. Application pressure pot and associated lines.

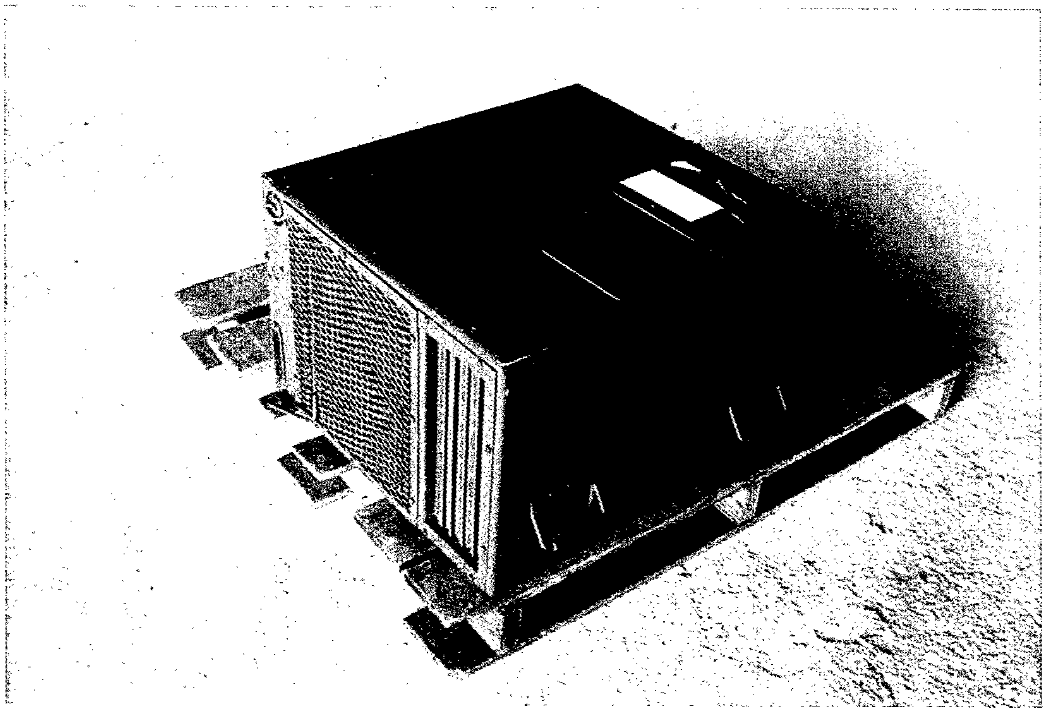

Figure 3. 9000-Btu AC unit before application of WD CARC.

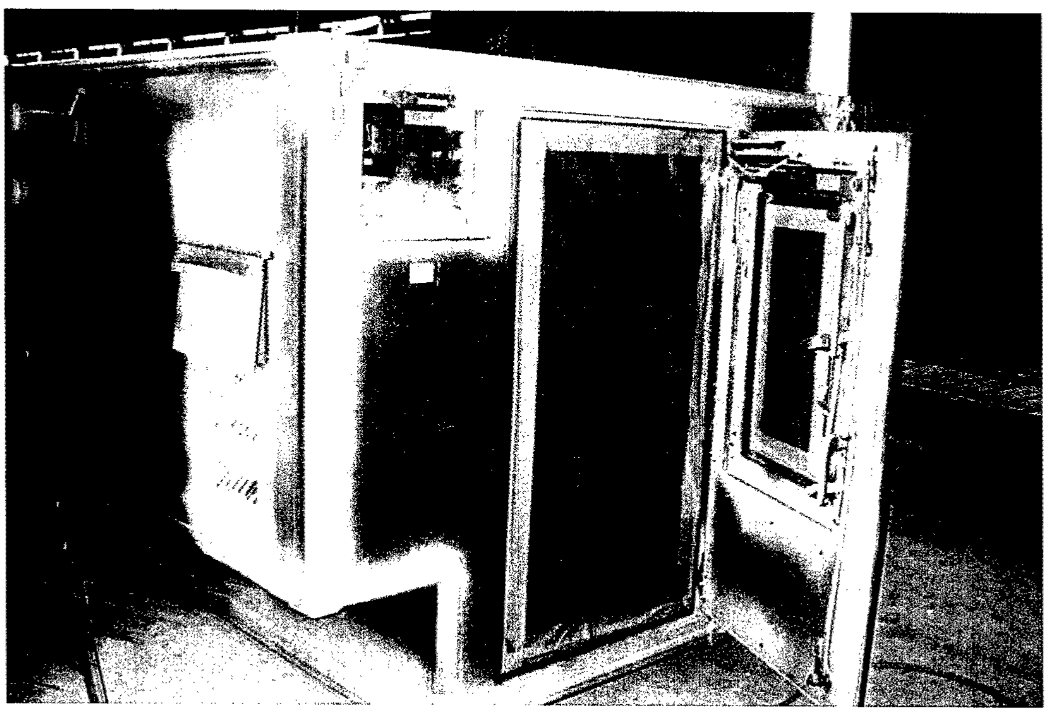

Figure 4. GMS-250 shelter before application of WD CARC.

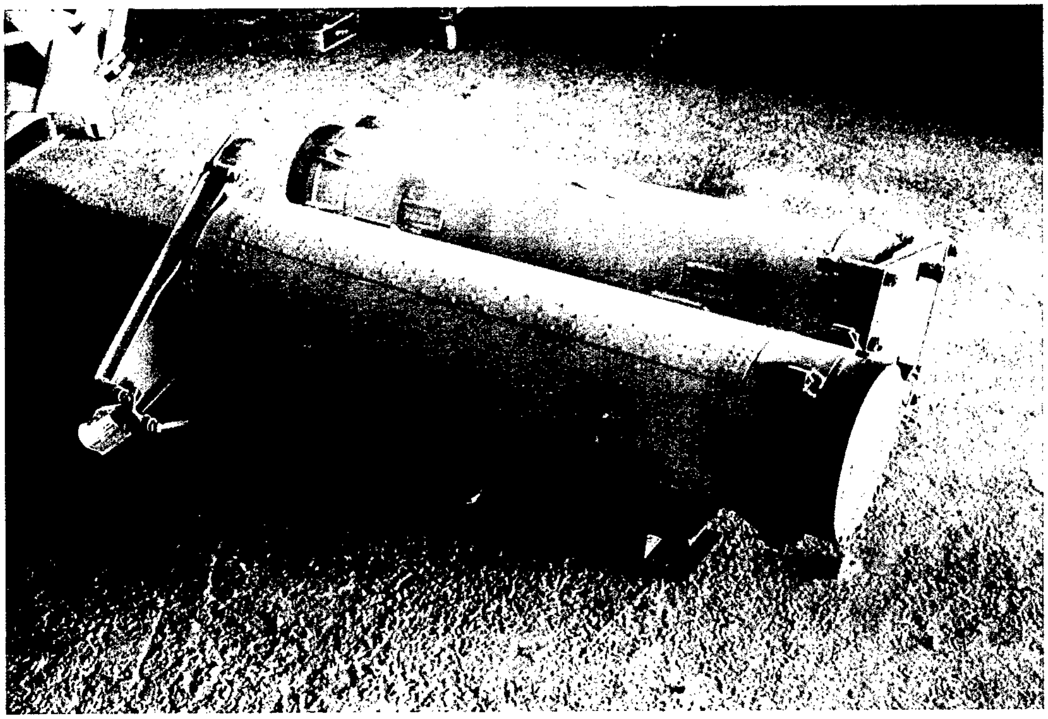

Figure 5. Small tripod legs before application of WD CARC.

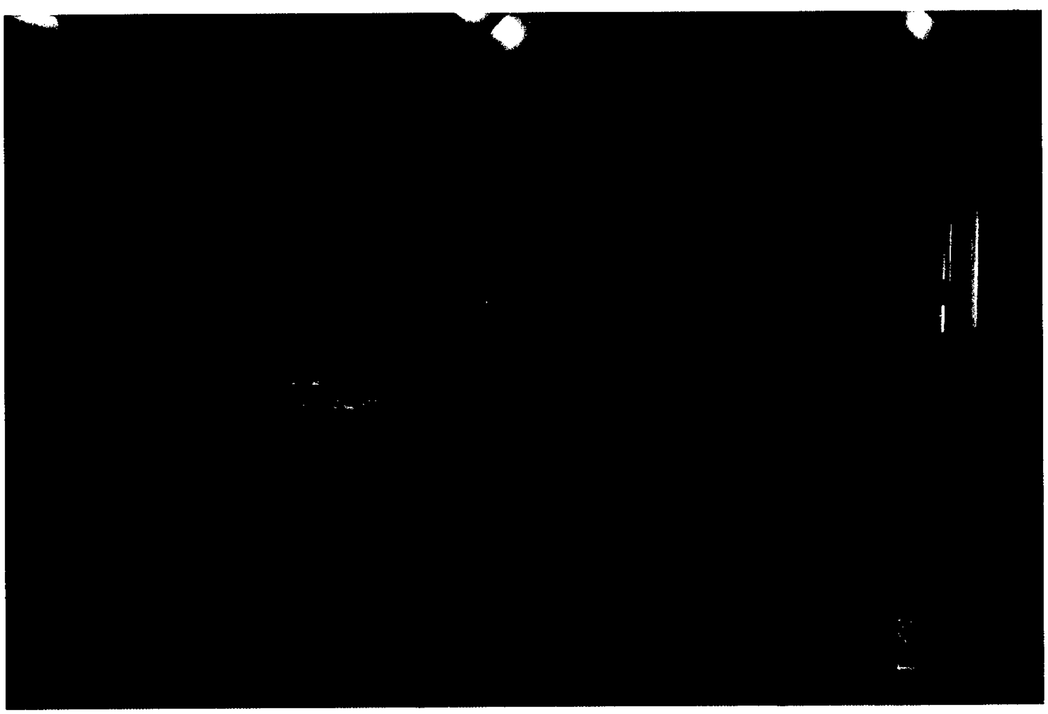

Figure 6. GMS-250 during application of WD CARC.

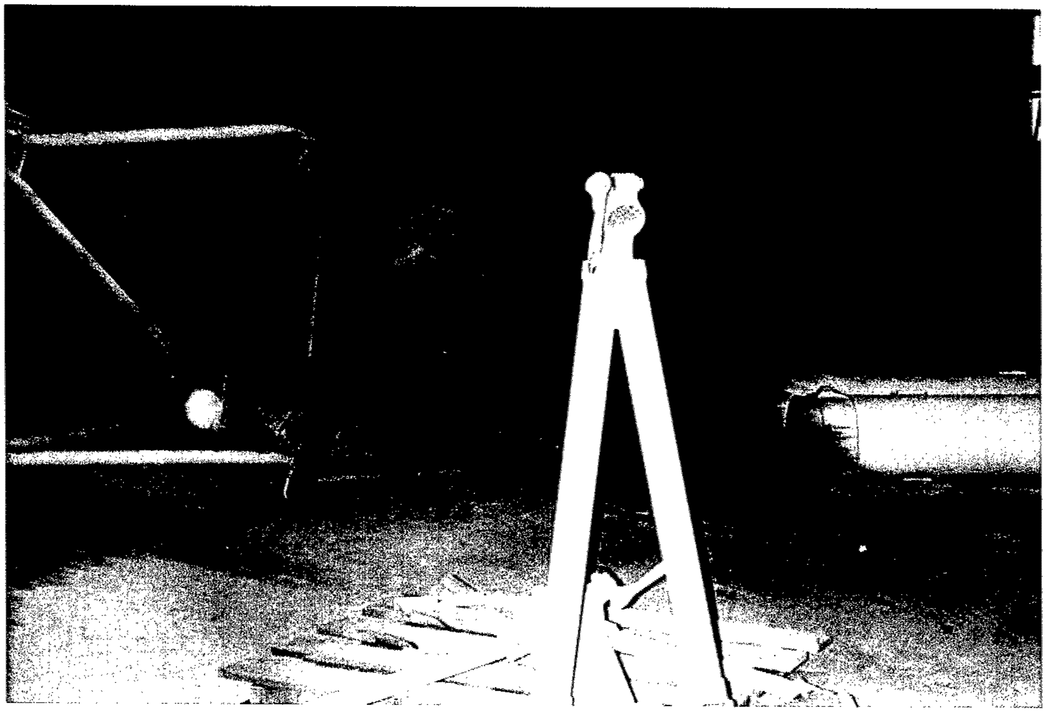

Figure 7. Antenna pedestal base during application of WD CARC.

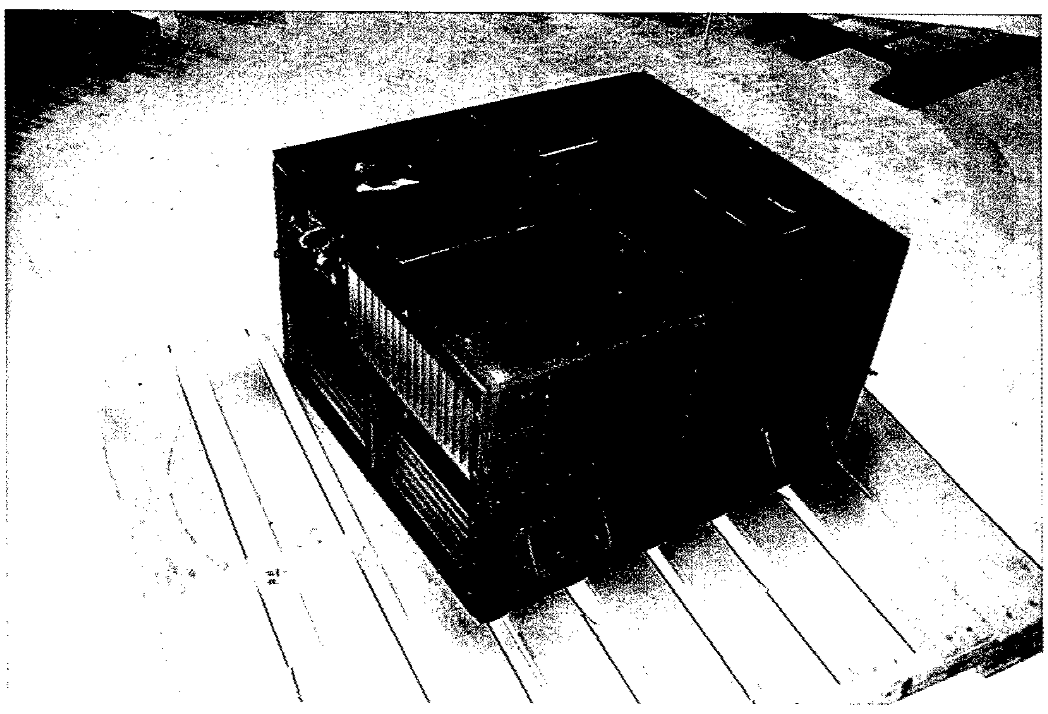

Figure 8. 9000-Btu AC unit after application of WD CARC.

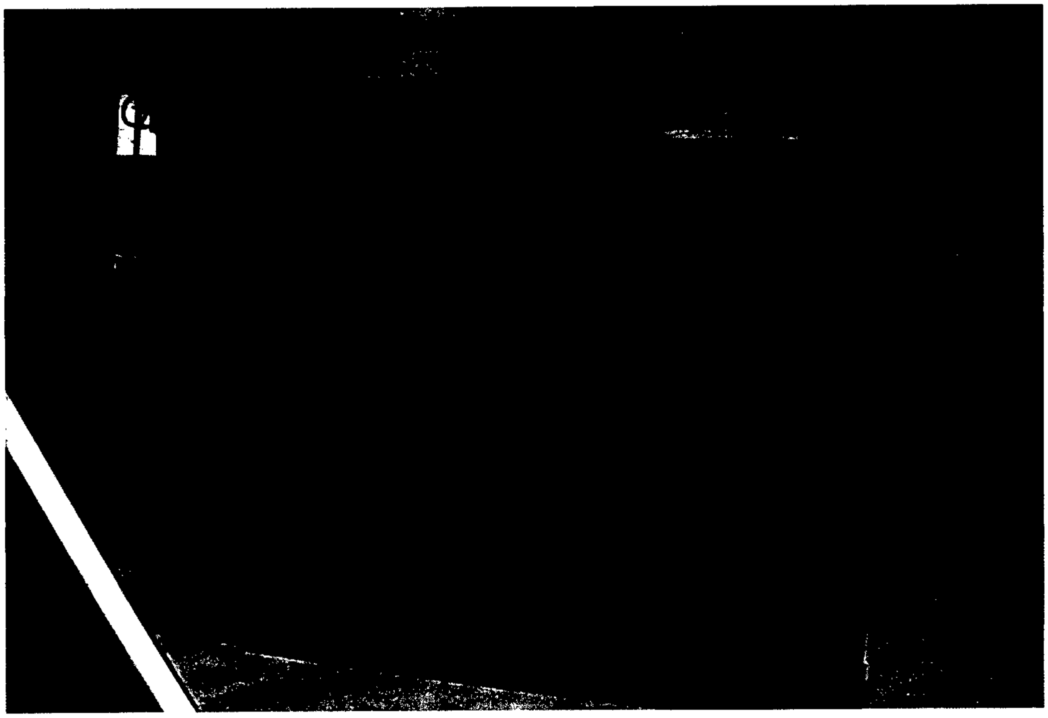

Figure 9. GMS-250 after application of WD CARC.

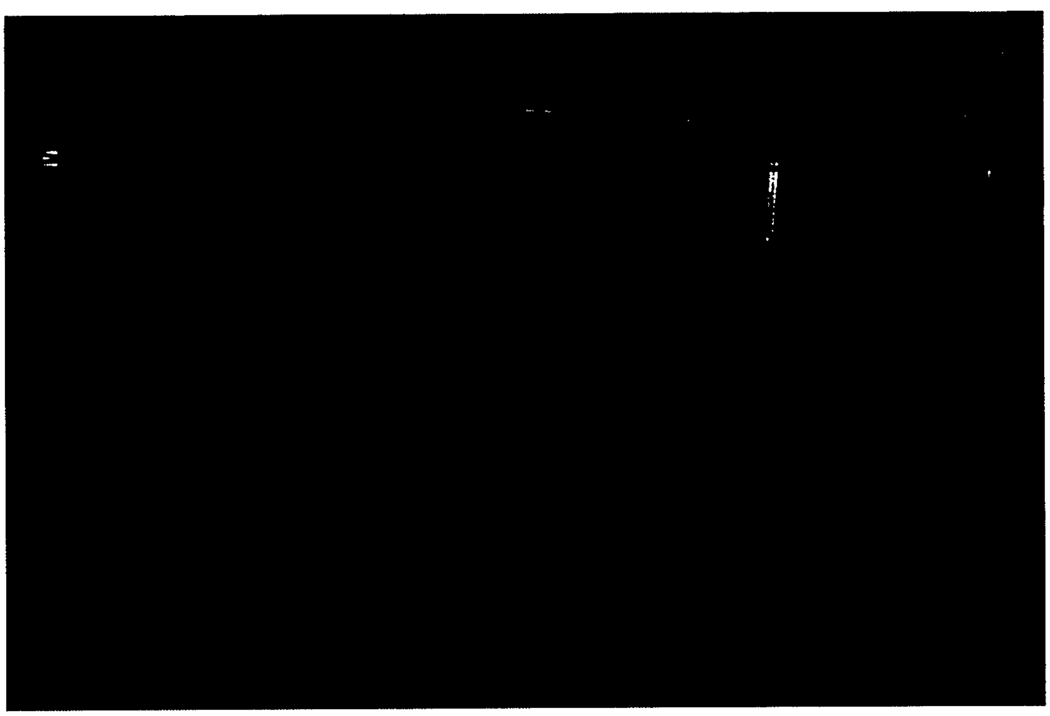

Figure 10. GMS-250 after application of WD CARC.

weathering (i.e., exterior weathering for panels prior to use at stripping demonstrations), coating thickness, pull-off adhesion testing, impact resistance, flexibility, abrasion resistance, sag resistance, and dynamic mechanical thermal analysis (DMTA). Specifically, ARL performed the tests related to survivability, both camouflage and chemical warfare, and durability (i.e., color and infrared reflectance, gloss, DS2 resistance, chemical agent resistance, dry film thickness, and accelerated weathering).

3.1 Color

The color of the applied WD CARC was measured using a DataColor International CS-5 Chroma Sensor spectrophotometer in accordance with ASTM D 2244 (*14*) using standard Illuminant C and the 2° observer data (Figure 11). The visual reflectance was 8.05, the chromaticity was (0.3217, 0.3616), the infrared reflectance average was 43.33%, the red region reflectance was 7.53%, and the infrared-to-red reflectance ratio was 5.75. All results fell within the requirements for camouflage Green 383.

3.2 Specular Gloss

The specular gloss of the applied WD CARC was measured with a Byk-Gardner haze-gloss reflectometer in accordance with ASTM D 523 (*15*). The 60° gloss was 0.7 and the 85° gloss was 1.6, both of which were well within the requirements for camouflage topcoats of 1.0 maximum and 3.5 maximum at 60° and 85°, respectively.

3.3 DS2 Resistance

The DS2 resistance test was performed in accordance with the requirements of MIL-DTL-64159 (*16*). The procedure is essentially a spot test, in which the cured coating is exposed to DS2 for 1/2 hr, rinsed, and checked for such defects as blistering, film softening, wrinkling, or color change. The only defect noted was a very slight color change of 0.5 National Bureau of Standards (NBS) units, well within the allowable maximum color change of 2.5 NBS units.

3.4 Chemical Agent Resistance

The chemical agent resistance test was performed in accordance with the requirements of MIL-DTL-64159. The procedure was updated in a joint effort between ARL and the U.S. Army Edgewood Chemical and Biological Center at Aberdeen Proving Ground and incorporates advances in instrumentation since the procedure developed for the original CARC topcoat specifications.

3.4.1 Panel Preparation

Spray steel panels, zinc phosphate pretreated according to TT-C-490, type 1, with epoxy primer conforming to MIL-P-53022 (*17*) or MIL-P-53030 to a dry film thickness between 0.0009 and 0.0011 in. Air dry 2 hr and spray the coating to be tested to a dry film thickness between 0.0018 and 0.0022 in. Air dry the panels for 7 days.

Batch Results

Sample - Tobyhanna ESTCP demo
Illuminant - C 2 Deg

Visible	380-480	490-590	600-700	Red avg. data		
		7.11	7.31			
		7.73	7.10			
	5.32	8.34	7.13	620 nm	7.13	
	5.44	8.96	7.31	630 nm	7.31	
	5.44	9.27	7.43	640 nm	7.43	X 2
	5.45	9.15	7.47	650 nm	7.47	X 3
	5.57	8.72	7.88	660 nm	7.88	X 3
	5.69	8.15	8.55			
	5.87	7.72	9.56			
	6.12	7.59	11.62			
	6.52	7.54	14.47			

X	Y	Z	x	y
7.16	8.05	7.05	0.3217	0.3616

Infrared	710-800	810-900	910-1000	1010-1100	IR avg. data
	19.19	48.23	49.48	55.74	24.06
	24.06	48.09	50.10	55.91	34.07
	29.15	47.99	50.76	55.90	42.44
	34.07	47.88	51.49	55.80	45.36
	38.54	47.84	52.23	55.54	47.17
	42.44	47.89	53.01	55.09	48.25
	45.36	47.98	53.70	54.51	48.23
	47.17	48.21	54.37	53.76	47.99
	48.05	48.51	54.91	52.89	47.88
	48.25	48.94	55.40	51.87	47.89

Figure 11. Reflectance results for TYAD demo Green 383.

3.4.2 Test Conditions

Because the desorption rate of agents from paint is temperature dependent, all agent tests will be conducted at 25 °C. Extremely toxic materials are used in this testing. Agent HD, a vesicant agent, is also a known carcinogen. Agent GD is a toxic nerve agent, exposure to which is difficult to treat. Consequently, all work will be performed in an approved fume hood, and appropriate measures to protect individuals at risk of exposure must be taken.

3.4.3 Test Apparatus

The test apparatus used for both HD and GD testing consist of a temperature controlled Plexiglas box (~0.5 × 0.5 × 1 m) containing five separate test cells. Four of these cells are used to test sample CARC panels; the fifth is used to test a control panel, all five tests to be run simultaneously. The test cells are machined from aluminum and consist of two parts that are clamped together to hold the test panels in place. A gastight seal is maintained by means of O-rings. Agent desorbed from the test panels is entrained by dry nitrogen that passes through a Miller-Nelson HCS401 temperature-humidity-flow controller, with final temperature controlled by a YSI Model 72 proportional temperature controller. The nitrogen passes through an external chamber fitted with a bleed valve before entering the test cells. Determine the agent recovered in micrograms.

3.4.4 Test Procedure

Place a 5-cm^2 circular template on the area of the test panel to be contaminated with agent. Use a grease pencil to mark a circle around the template; the grease mark serves to keep the agent from spreading out of the designated area. Place 50 μL of agent (HD or GD) on the test area using a microliter syringe. Place a glass cover slip (microscope slide) over the test area to minimize evaporation of the agent. After 30 min remove the cover slip, rinse the agent from the panel with isopropanol, and allow to air dry for ~45 s. Place the panel in the test cell, which has been maintained at 25 °C, with the coated area positioned such that the nitrogen stream will pass across the contaminated area. Nitrogen is used instead of air to eliminate the possibility of reaction of the desorbed agent over the time of the test, which is 22 hr. Pass the nitrogen through an impinger containing the appropriate solvent, n-decane for HD and iso-octane (2,2,4-trimethylpentane) for GD. The flow of nitrogen across each sample shall be 200 mL/min, maintained by mass flow controllers. Terminate the test at the end of 22 hr.

3.4.5 Analysis

Transfer the contents of each impinger to a 25-mL volumetric flask. Rinse the impinger twice with the same solvent and add the rinse to the flask. Bring the volume up to the mark with solvent and mix well. Transfer a 1-mL portion to a GC vial for analysis. Perform the analysis on a Finnigan-MAT GQC ion-trap mass spectrometer equipped with a 25-m MS-5 capillary column, using helium as the carrier gas. Standardize the mass spectrometer by serial dilutions of an agent solution in the appropriate solvent, analyzed in the same conditions. The instrument conditions are as follows: introduce the samples from an AST 2000 autosampler, volume of 1 μL, onto the GC column in splitless mode; injector temperature of 280 °C. Temperature program the column from an initial temperature of 50 °C to 120 °C at a rate of 10°/min, followed by an increase of 25 °C/min to a final temperature of 200 °C. Acquire mass spectra in electron impact mode over the mass range of 50–150 for HD and 50–200 for GD. Under these conditions, HD has a retention time of 8.15 min. Integrate the peak areas of the relevant portion of the reconstructed ion chromatograms for the ion at m/z 109. Under the cited conditions GD elutes as a pair of completely resolved diastereomeric enantiomers with retention times of 9.56 and 10.04 min. Integrate the peak areas of the relevant portion of the reconstructed ion chromatograms for the ion at m/z 99. Construct the standard response curve for HD and GD using the integrated area on the y-axis and concentration (microgram per milliliter) on the x-axis. Use the linear regression analysis function of a Microsoft Excel spreadsheet, which will calculate the slope, intercept, and correlation coefficient of the standard response curve. The slope and intercept of the standard response curve are used to calculate concentration of agent (HD or GD) in the impinger solutions. Calculate the total amount of agent (in micrograms) that outgassed from the CARC panel by multiplying the concentration of agent in the impinger solution (micrograms per milliliter read from the standard curve) by the volume of the impinger solution (25 mL).

The result for S-W formula F93G502/V93V502 was less than 10 $\mu g/cm^2$, well within the maximum allowable of 180 $\mu g/cm^2$ for agent HD.

3.5 Dry Film Thickness

The film thickness of the MIL-P-53030 primer applied to the test panels was measured with an electronic film thickness tester after the overnight cure and before the WD CARC topcoat was applied. One reading was taken for each of the 50 panels, and the electronic tester provided the resultant statistics. The average was 2.01 mils, with a standard deviation of 0.21 mils. The maximum reading was 2.37 mils, and the minimum reading was 1.43 mils. While this is slightly thicker than necessary, the results are acceptable in accordance with a minimum thickness of 1.5 mils indicated by MIL-C-53072 (*18*). The WD CARC film thickness was checked for the test panels and for the GMS-280 shelter painted on the second day of the demonstration. In the case of the test panels, the film thickness was measured after application of the topcoat to the primed panels. This was determined to be an average of 5.07 mils, with a standard deviation of 0.52 mils, yielding (by subtraction) about 3 mils of topcoat. Again, this is slightly thicker than required, but acceptable per MIL-C-53072. In the case of the shelter, bare test panels were affixed to the shelter on the ID plates, which had been masked to keep the paint off. The film thicknesses of two such test panels was determined to be 3.02 mils with a standard deviation of 0.15 mils, and 2.62 mils with a standard deviation of 0.16 mils. This indicates that not only was the thickness on the painted equipment acceptable, but also that it was reasonably close to the film thickness obtained for the validation test panels.

3.6 Accelerated Weathering

The accelerated weathering was performed to evaluate the color durability of the WD CARC. Four panels each were subjected to 6000 hr of American Society for Testing and Materials Standard (ASTM) G 155 (*19*) and 6000 hr of ASTM G 154 (*20*). Xenon arc exposure used the standard procedure of 108 min of light exposure and 12 min of light exposure and direct deionized water spray in each 2-hr cycle. The ultraviolet (UV) exposure used the standard procedure of 8 hr of light exposure and 4 hr of darkness with condensation in each 12-hr cycle.

Color data for one of the four panels tested in each type of accelerated weathering are shown in Table 1 (xenon arc) and Table 2 (UV). The tristimulus values (X, Y, and Z) and chromaticity coordinates (x, y), and the NBS color difference are listed after each increment of exposure, 300 hr in the case of xenon arc, and 500 hr in the case of UV. The average results for the four panels in xenon arc are plotted in Figure 12, along with data from the baseline Green 383 from MIL-C-46168, and lab batches of MIL-DTL-64159, type I (siliceous extenders) and MIL-DTL-64159, type II (SERDP/ESTCP WD CARC). The average results for the four panels in UV are plotted in Figure 13. Since there is no baseline UV data available for the MIL-C-46168, MIL-DTL-64159, type I (siliceous extenders) or MIL-DTL-64159, type II (SERDP/ESTCP WD CARC), the xenon arc data for MIL-C-46168 and the WD CARC are shown for reference. The WD CARC exhibits resistance to accelerated weathering that can only be described as exceptional, since the color change after 6000 hr of exposure is less than the 2.5 units allowed for solvent-borne CARC topcoats after 300 hr exposure; i.e., one-half to two-thirds of the allowable color change after 20 times the exposure period.

4. Verification Testing: NSWCCD

4.1 Tensile Adhesion

Tensile adhesion tests were performed on the coated panels to quantify the amount of force necessary to break the bond of the coating to the substrate. Testing was performed in accordance with ASTM D 4541 (*21*) using a type VI PATTI self-alignment adhesion tester with an F-8 piston.

The test was performed on six 3- × 6- × 1/8-in panels. The objective was to compare the data to that obtained from the baseline testing of the same coating system applied in a laboratory setting.

Results of the PATTI adhesion testing produced an average pull-off-strength (POS) of roughly 800–900 pounds per square inch (psi), as shown in Table 3. This is actually a slight improvement from the thin panel results obtained from the baseline SERDP testing, which

Table 1. Xenon arc weathering data (panel A).

Time (hr)	**X**	**Y**	**Z**	**x**	**y**	ΔE_{NBS}
START	7.14	8.03	7.05	0.321	0.361	0.00
300	7.49	8.45	7.49	0.320	0.361	0.81
600	7.59	8.58	7.61	0.319	0.361	1.08
900	7.63	8.62	7.66	0.319	0.361	1.13
1200	7.64	8.66	7.68	0.319	0.361	1.32
1500	7.65	8.68	7.68	0.319	0.362	1.37
1800	7.65	8.69	7.67	0.319	0.362	1.42
2100	7.63	8.67	7.63	0.319	0.362	1.39
2400	7.60	8.64	7.58	0.319	0.363	1.36
2700	7.61	8.64	7.57	0.319	0.363	1.27
3000	7.61	8.65	7.55	0.320	0.363	1.33
3300	7.61	8.67	7.54	0.319	0.364	1.47
3600	7.63	8.71	7.56	0.319	0.364	1.63
3900	7.63	8.71	7.55	0.319	0.365	1.63
4200	7.60	8.67	7.49	0.320	0.365	1.53
4500	7.62	8.69	7.49	0.320	0.365	1.53
4800	7.66	8.75	7.53	0.320	0.365	1.70
5100	7.66	8.76	7.52	0.320	0.366	1.78
5400	7.68	8.79	7.53	0.320	0.366	1.86
5700	7.67	8.78	7.51	0.320	0.366	1.86
6000	7.65	8.76	7.50	0.320	0.366	1.86

Table 2. UV weathering data (panel A).

Time (hr)	**X**	**Y**	**Z**	**x**	**y**	ΔE_{NBS}
START	7.15	8.05	7.05	0.321	0.362	0.00
500	7.54	8.50	7.49	0.320	0.361	0.76
1000	7.60	8.58	7.57	0.320	0.361	0.93
1500	7.61	8.59	7.59	0.320	0.361	0.95
2000	7.65	8.63	7.64	0.320	0.361	1.01
2500	7.73	8.72	7.72	0.320	0.361	1.14
3000	7.70	8.69	7.67	0.320	0.361	1.08
3500	7.76	8.77	7.71	0.320	0.362	1.21
4000	7.80	8.83	7.75	0.320	0.362	1.35
4500	7.80	8.82	7.74	0.320	0.362	1.29
5000	7.82	8.86	7.74	0.320	0.363	1.40
5500	7.84	8.89	7.77	0.320	0.363	1.47
6000	7.83	8.88	7.75	0.320	0.363	1.46

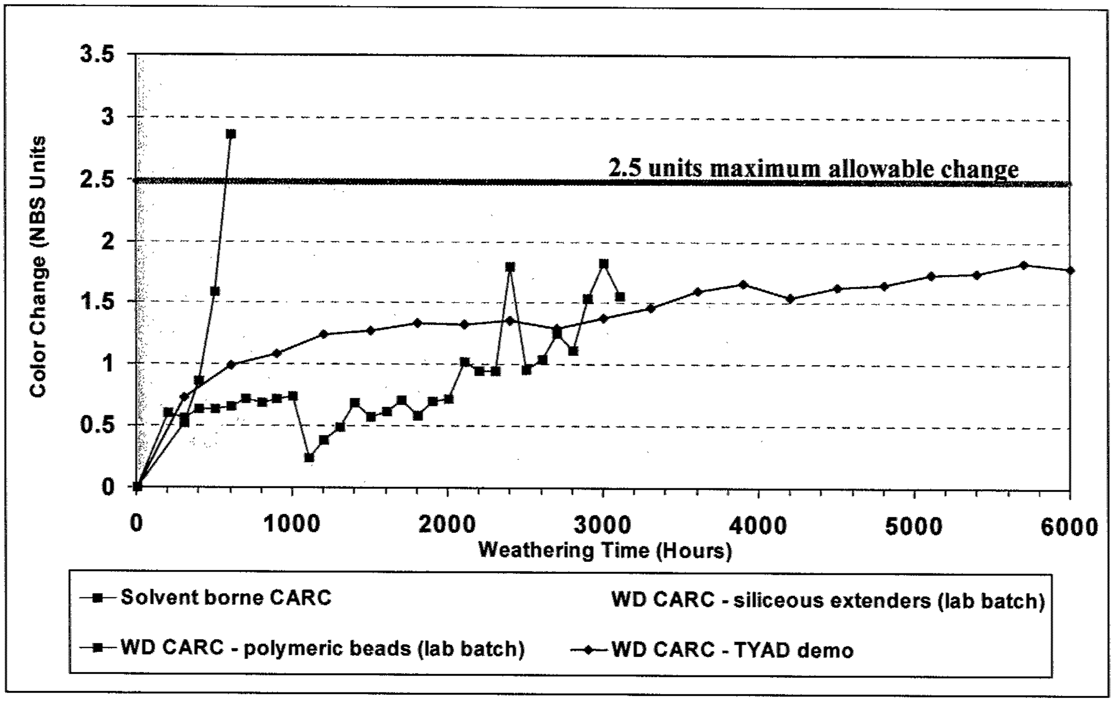

Figure 12. Xenon arc accelerated weathering.

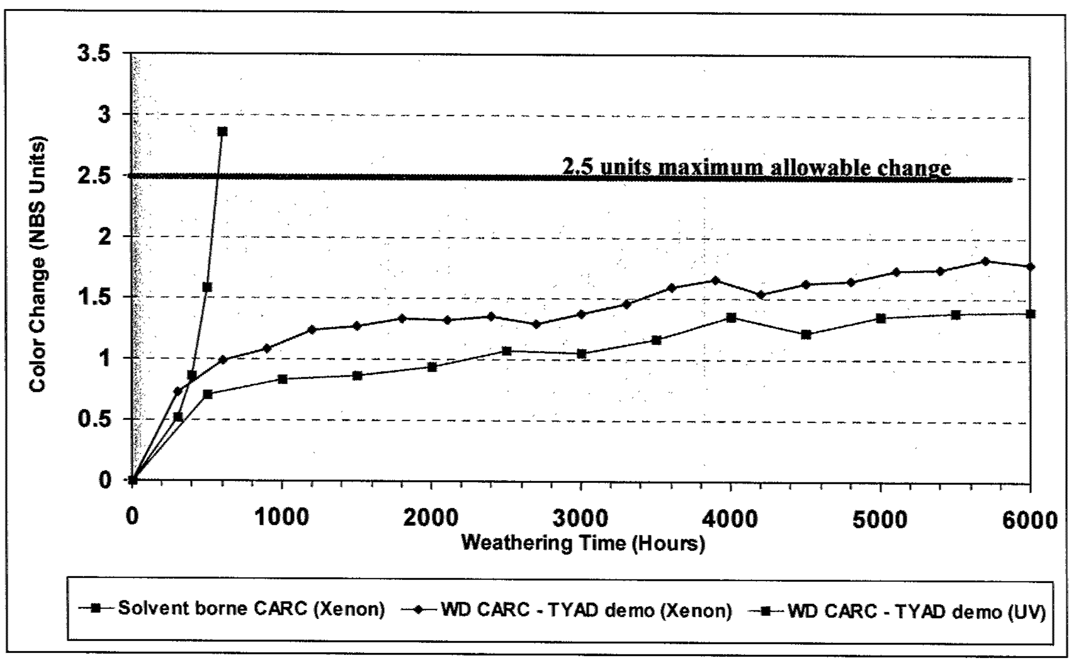

Figure 13. UV accelerated weathering.

Table 3. PATTI pull-off adhesion strength.

Primer	Test Date	Test No. (psi)						Average	Standard Deviation
		1	2	3	4	5	6		
MIL-P-53030	27 Nov 00	914	935	935	935	935	894	925	17
None	27 Nov 00	833	853	812	812	853	NA	833	21

Note: NA = not available

produced an average POS of ~500 psi for primer and WD CARC to steel, although the primer used in the baseline testing was MIL-P-53022.

4.2 Direct Impact Resistance

Impact resistance testing was performed to provide insight into the flexibility characteristics of the cured film and to validate the expected physical properties of the cured film. The testing was in accordance with ASTM D 2794 (*22*), and the substrate was 2024 aluminum alloy (0 temper) with chromic acid anodize pretreatment (MIL-C-8625, type I). Results are summarized in Table 4 and are consistent with panel results obtained from the baseline SERDP testing.

Table 4. Impact resistance and flexibility.

Primer	Impact Resistance		GE Impact Flexibility (%)	Mandrel Bend Resistance (in)
	Direct (in-lb)	Reverse (in-lb)		
None	15	<1	5	0.125
MIL-P-53030	7	<1	2	1

4.3 Cylindrical Mandrel Bend

Mandrel bend flexibility and elongation characteristics were also determined to obtain further insight into the flexibility characteristics of the cured film and to validate the expected physical properties of the cured film. The testing was performed in accordance with ASTM D 522 (*23*) on a 2024 aluminum alloy (0 temper) with chromic acid anodize pretreatment (MIL-C-8625, type I) substrate. These results are also shown in Table 4 and are consistent with panel results obtained from the baseline SERDP testing.

5. Verification Testing: AFRL

The Air Force responsibility in the dem/val was to validate that stripping the WD CARC could be accomplished as a "drop-in" procedure, using current production equipment. The test panels prepared at this demo were both steel and aluminum panels. The steel panels were pretreated with zinc phosphate by Metal Samples, Inc., and the aluminum panels were provided with a chromate conversion pretreatment per MIL-C-5541, class 1A. Roughly one-fourth of the total was dedicated to each of four possible stripping processes: (1) plastic media blast, (2) steel shot blast, (3) garnet blast, or (4) chemical stripping. The panels were to be EMMAQUA weathered for ~10 months before the stripping demo, scheduled for November 2001.

6. Conclusions

The application of the WD CARC to the variety of military hardware at TYAD demonstrated the "drop-in" nature of the WD CARC system. The WD CARC was a production batch manufactured by the Sherwin-Williams Company, and it was applied using standard production equipment under normal environmental conditions. Surveys completed by the depot applicators indicated that the WD CARC was considered overall to be a better coating than the MIL-C-53039 normally used. In addition, laboratory testing completed on the coated panels indicates similar test results to the SERDP program testing of the baseline WD CARC. This improved performance in outdoor durability should lengthen the time between refinishing, and the improved mar resistance and flexibility should mitigate surface damage due to abrasion and result in less refinishing of military equipment on the basis of cosmetic appearance.

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Appendix A. Tobyhanna Army Depot (TYAD) Pre-Demonstration Briefing

This appendix appears in its original form, without editorial change.

Weapons and Materials Research Directorate

DEMONSTRATION/VALIDATION OF LOW VOC WATER DISPERSIBLE CHEMICAL AGENT RESISTANT COATING (WDCARC)

Planning Meeting
Tobyhanna AD
12 September 2000

BACKGROUND

Weapons and Materials Research Directorate

SERDP Project

- 3 year effort (FY97 - FY99)
- Tri-Service participation
  - ARMY
    - Program Management (ARDEC)
    - Formulation (ARL)
    - Specification Authority (ARL)
  - Navy/ MARINE CORPS
    - Application Procedures (NSWC)
  - AIR FORCE
    - Stripping/Removal Procedures (AFRL)

KEY PERSONNEL

Weapons and Materials Research Directorate

- Program Manager
  - US Army Armament Research, Development, & Engineering Center
    - Robert Katz
- Principal Investigators
  - US Army Research Lab (ARL), Polymers Research Branch, Aberdeen Proving Ground, MD
    - Jeffrey Duncan - CARC formulation and specification
    - John Escarsega - CARC formulation and specification
  - Naval Surface Warfare Center, Carderock Division, Philadelphia, PA
    - Malay Patel - Lead Marine Corps CARC Engineer
    - Anthony Eng - Marine Corps Applications Engineer
  - Air Force Research Lab, Wright-Patterson AFB
    - William Hoogsteden - Lead Air Force CARC Engineer
    - Charles Cundiff - SwRI Depaint Engineer

OBJECTIVES

Weapons and Materials Research Directorate

- Develop a CARC topcoat that can be used by multiple services
  - Environmentally compliant
  - Chemical Agent Resistant
  - Satisfies camouflage & performance requirements of each using Agency
- "Drop-in" Substitute for current CARC coatings

CARC DEVELOPMENT HISTORY

Weapons and Materials Research Directorate

- ARMY
  - Designed to reduce/eliminate VOC & HAPS
  - Development of WDCARC begins
  - MIL-C-64159 Type I developed
    - finished July 99
- MARINE CORPS
  - Environmental restrictions Prevent use of currently approved topcoats
  - Barstow stops MIL-C-46168
  - USMC begins WDCARC development
  - WBCC developed
    - not agent resistant
    - adopted as interim solution

•Joint Effort
- SERDP effort begins
- Eventually leads to MIL-C-64159 Type II material

ESTCP effort

SERDP ACCOMPLISHMENTS

Weapons and Materials Research Directorate

- Formulation developed, patented, & qualification in progress
  - VOC reduced from 3.5 lbs./gal to under 1.8 lbs./gal
  - Hazardous Air Pollutants (HAPS) eliminated
- Performance of coating enhanced significantly
  - Improved flexibility
  - Improved weatherability
  - Improved mar resistance
- Application/Stripping Studies completed: procedures drafted
  - Laboratory studies indicate "drop-in" nature achieved
- Draft specification - parameters being established

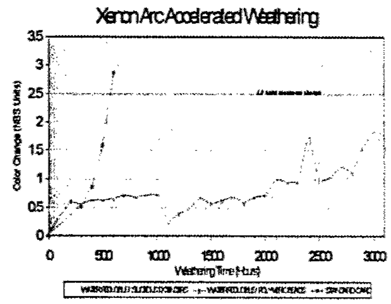
CARC FORMULATIONS

Weapons and Materials Research Directorate

CURRENT CARC (MIL-C-46168)	INTERIM ARMY WDCARC (MIL-C-64159 - Type I)	SERDP WDCARC (MIL-C-64159 - Type II)
• Solvent Base Resin System • HAP Solvents • Reduction With HAP Solvents • Use of Siliceous Type Flattening Agents • Easily Marred • Chalks Due to Siliceous Materials • Minimal Flexibility	• Water Dispersible Resin System • Major Solvents Non-HAP • Reduction with Water • Use of Siliceous Type Flattening Agents • Moderate Marring • Enhanced Weather Resistance • Moderate Flexibility • Material available July 99	• Water Dispersible Resin System • Major Solvents Non-HAP • Reduction with Water • Use of Polymeric Beads as Flattening Agents • Non-Marring • Superior Weather Resistance • Excellent Flexibility • Implementation Late FY 00-01

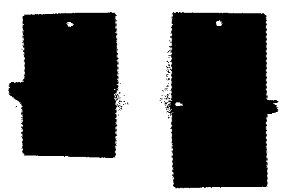
ACCELERATED WEATHERING

Weapons and Materials Research Directorate



FLEXIBILITY

Weapons and Materials Research Directorate



Water-dispersible CARC
1/8 inch mandrel bend
at -54° C

Conventional CARC
1/8 inch mandrel bend
at 0° C

ESTCP EFFORT - BACKGROUND

Weapons and Materials Research Directorate

- Two-year effort
- Objectives
  - Demonstrate/validate processes and performance
- Participation
  - Marine Corps - Marine Corps Logistics Base, Barstow, CA
    - Application - May 9-11, 2000, Removal - April '01
  - Air Force - Ogden Air Force Logistics Center, UT
    - Application - Aug 29-31, 2000 , Removal - July '01
  - Army - Tobyhanna Army Depot, PA
    - Application - Oct 2000 , Removal - Aug '01

ESTCP EFFORT - TECHNICAL

Weapons and Materials Research Directorate

- Application/Coating performance validation
  - Apply coatings to equipment
    - 3-4 Pieces
  - Apply coatings to panels
  - Specific panels returned to labs for performance validation
- Stripping Process Validation
  - Specific panels aged via accelerated exposure for about 11 months
  - Aged panels returned to demo facility for stripping validation

MIL-C-64159 SPECIFICATION

Weapons and Materials Research Directorate

- Status
  - Draft specification by ARL in progress
- Two Types
  - Type I - Water Dispersible with siliceous flatteners (Army Interim)
  - Type II - Water Dispersible with polymeric flatteners (Tri-Service SERDP)
- NSN assignment upon completion of draft specification

BARSTOW ESTCP LOW VOC WDCARC DEMO RESULTS

- 4 Vehicles Painted With Green 383 Low VOC WDCARC
  - 2 HMMWVs
  - 1 5-Ton Truck
  - 1 Light Armored Vehicle (LAV)
- Laboratory Test Panels and Accelerated Aging Panels Painted
- Painters Indicated Acceptable Spraying Properties

OGDEN ESTCP LOW VOC WDCARC DEMO RESULTS

- Three 100 KW Generators and one 5 KW Generator Painted With Green 383 Low VOC WDCARC
- Laboratory Test Panels and Accelerated Aging Panels Painted
- Painters Indicated Acceptable Spraying Properties

TOBYHANNA DISCUSSION TOPICS

- Types and Mix of Equipment to Be Coated
  - Generators, Shelters, Vehicles?
- Amount of WDCARC Required for Equipment
- Pretreatment & Primers
  - What Types?
  - Who Does These?
- TYAD Issues/Concerns?

Appendix B. Tobyhanna Army Depot (TYAD) Demonstration Letter

This appendix appears in its original form, without editorial change.

DEPARTMENT OF THE ARMY
UNITED STATES ARMY RESEARCH LABORATORY
ABERDEEN PROVING GROUND MD 21005-5069

REPLY TO
THE ATTENTION OF

October 24, 2000

Polymers Research Branch

MEMORANDUM FOR Tobyhanna Army Depot, 11 Hap Arnold Blvd., ATTN: Donald Carroll, Director/Production Support Services, Tobyhanna, PA 18466

SUBJECT: Environmental Security Technology Certification Program (ESTCP) Demonstration/Validation Of Low Volatile Organic Compound (VOC) Chemical Agent Resistant Coating (CARC)

1. Reference meeting between ESTCP Team and Tobyhanna AD personnel on 13 September 2000.

2. The Strategic Environmental Research and Development Program (SERDP) funded a tri-Service effort to develop a low Volatile Organic Compound (VOC) Chemical Agent Resistant Coating (CARC) - Project PP #1056, for use on Army, Marine Corps, and Air Force equipment. The coating must comply with current and anticipated regulatory requirements for VOC content and eliminate hazardous air pollutants (HAPs) and toxic solvents used in current CARC formulations. Additionally, the new formulation must meet performance requirements for all three Agencies. The effort was initiated in fiscal year (FY) 1997 and was funded by SERDP through FY 1999.

3. The technical effort was divided into three phases - formulation, application, and stripping, with each Agency overseeing one of the phases. The Army Research Lab (ARL) Coatings Technologies Team conducted the formulation efforts, Naval Surface Warfare Center, Carderock Division (NSWCCD) performed the application studies, and Air Force Research Labs (AFRL), along with Southwest Research, Inc., performed the de-paint or stripping studies.

4. Using recent developments in polymer and pigmentation technology, ARL was successful in developing a high performance water dispersible (WD) CARC polyurethane topcoat. The formulation developed under the SERDP Project succeeded in meeting the VOC objective of 1.8 lbs./gal, and it has eliminated hazardous air pollutants as well. In addition to be being fully environmentally compliant, the new coating shows significant performance enhancements, as evidenced by improvements in low temperature flexibility, mar resistance, and weathering durability. ARL has prepared a draft specification for this material, which will be designated MIL-C-64159, Type II - Coating, Water Dispersible Aliphatic Polyurethane, Chemical Agent Resistant.

5. Beginning in FY 2000, the SERDP effort evolved into ESTCP number 200024, Demonstration/Validation of Low Volatile Organic Compound (VOC) Chemical Agent Resistant

Coating, with the same team members. ESTCP's charter is to demonstrate/validate promising technologies, developed under the SERDP program or elsewhere, which may result in a positive environmental impact. The technology to be demonstrated/validated under this ESTCP effort is the low VOC WD CARC developed via the above SERDP effort.

6. The objective of this demonstration/validation (dem/val) project is to prove the application of the new low VOC WD CARC formulation to defense materiel under production conditions. The trials will also serve to develop costs associated with application and performance data of the cured film applied under production conditions. Stripping trials will be performed to validate the ability to successfully remove the coating in a cost-effective manner. The demonstrations will validate that the new WD CARC coating can be applied and stripped utilizing existing equipment at the depots, in a cost-effective manner, when following the process guidelines as developed by the SERDP effort.

7. Dem/val efforts will be conducted at three facilities, one for each of the services that will be utilizing the WD CARC coating. The following locations have been selected and have agreed to participate in the program:

United States Marine Corps - Marine Corps Logistics Base - Barstow, CA
United States Air Force - Ogden Air Logistics Center, Ogden, UT
United States Army - Tobyhanna Army Depot, Tobyhanna, PA

8. The demonstration plan consists of the following:

A. Pre-Demonstration

During the referenced meeting, details for the demonstration at Tobyhanna Army Depot (TYAD) were discussed and finalized. The ESTCP team provided TYAD personnel with background information about the coating, focused on the SERDP efforts, application, anticipated performance, stripping considerations, safety and environmental issues, availability, and implementation plans. The demonstration will occur the week of 30 OCT 2000. TYAD has agreed to provide three to five production-type items for the demonstration.

B. Application Validation

The ESTCP team will be on-site during the application process to provide technical support and to document details of the demonstration. Application process will be conducted in accordance with standard Army procedures and health and safety guidelines. Information such as vehicle identification numbers, materials, materials batch numbers, surface preparation, environmental conditions, application chronology, film thickness, and problems experienced will be recorded. An application data form, provided as enclosure (1), will be used to organize this information and archive it into a database. The chronology will be used to assess the impact on production rates, and hence, economic impact on the application process. Additionally, a survey will be given to the TYAD applicators to further assess the impact on the application process. This survey is provided as enclosure (2). Application procedures will be provided via separate correspondence.

C. Cured-Film Physical Property/Performance Validation

A panel test matrix has been developed to assess the cured-film physical properties and performance applied under production conditions. This matrix is provided as enclosure (3). Pretreated panels will be provided to TYAD for application of the primer and topcoat, concurrently with the vehicles. Enclosure (4) provides a detailed description of physical property testing which NSWCCD will perform. Data from the panels will be compared to laboratory/field data obtained from the SERDP effort to validate physical properties and performance.

D. Government Furnished Material

The ESTCP team will provide all of the WD CARC paint necessary to conduct the vehicle demonstrations and panel applications. Product Data Sheets and Material Safety Data Sheets (MSDS) will be forwarded prior to the demonstrations. Pretreated panels for the test matrix will be provided. TYAD will only be responsible for the application of the primer and topcoat to the panels. TYAD will be responsible for providing the vehicles, surface preparation and pre-treatment of vehicles, application equipment, and primer materials.

9. Questions or concerns about the ESTCP Low VOC CARC demonstration can be referred to Jeff Duncan at DSN 458-0690, commercial (410) 306-0690, or e-mail, jduncan@arl.army.mil.

/s/
Richard J. Shuford
Chief, Polymers Research Branch

4 Enclosures:
as

CC:
USA TACOM-ARDEC (Robert Katz) (w/o incl)

Appendix C. Painters' Surveys

This appendix appears in its original form, without editorial change.

Bldg 4 Paint Shop -- Bob #2

MIL-P-64159 TYPE II WRCARC FIELD TRIAL APPLICATION SURVEY

Fill out the correct column, based on which coating is currently used

WBCC

How would you describe the mixing of this material when compared to WBCC?

1. With respect to complexity of mix ratio:
Much Easier | Easier | Same
More Difficult | Much More Difficult

2. With respect to mixing:
Much Easier | Easier | Same
More Difficult | Much More Difficult

3. With respect to time:
Much Slower | Slower | Same
Quicker | Much Quicker

Additional comments:

How would you describe the spray characteristics of this material when compared to WBCC?

1. With respect to spraying:
Much Easier | Easier | Same
More Difficult | Much More Difficult

2. With respect to spray quality:
Much Worse | Worse | Same
Better | Much Better

3. With respect to application rate:
Much Slower | Slower | Same
Quicker | Much Quicker

4. With respect to wet film quality (i.e. orange peel, pinholes, sags, etc.):
Much Worse | Worse | Same
Better | Much Better

Additional comments:

What is your general opinion of this material compared to WBCC?

Much Worse | Worse | Same
Better | Much Better

Please use back of form to provide any additional comments about the material.

Solvent Based CARC

How would you describe the mixing of this material when compared to solvent based CARC?

1. With respect to complexity of mix ratio:
Much Easier | Easier | Same
More Difficult | Much More Difficult

2. With respect to mixing:
Much Easier | Easier | Same
More Difficult | Much More Difficult

3. With respect to time:
Much Slower | Slower | Same
Quicker | Much Quicker

Additional comments:

How would you describe the spray characteristics of this material when compared to solvent based CARC?

1. With respect to spraying:
Much Easier | Easier | Same
More Difficult | Much More Difficult

2. With respect to spray quality:
Much Worse | Worse | Same
Better | Much Better

3. With respect to application rate:
Much Slower | Slower | Same
Quicker | Much Quicker

4. With respect to wet film quality (i.e. orange peel, pinholes, sags, etc.):
Much Worse | Worse | Same
Better | Much Better

Additional comments:

What is your general opinion of this material compared to solvent based CARC?

Much Worse | Worse | Same
Better | Much Better

Please use back of form to provide any additional comments about the material.

Bldg 1B Paint Shop Ron Jeffery

MIL-P-64159 TYPE II WRCARC FIELD TRIAL APPLICATION SURVEY

Fill out the correct column, based on which coating is currently used

WBCC

How would you describe the mixing of this material when compared to WBCC?

1. With respect to complexity of mix ratio:
☐ Much Easier ☐ Easier ☐ Same
☐ More Difficult ☐ Much More Difficult

2. With respect to mixing:
☐ Much Easier ☐ Easier ☐ Same
☐ More Difficult ☐ Much More Difficult

3. With respect to time:
☐ Much Slower ☐ Slower ☐ Same
☐ Quicker ☐ Much Quicker

Additional comments:

How would you describe the spray characteristics of this material when compared to WBCC?

1. With respect to spraying:
☐ Much Easier ☐ Easier ☐ Same
☐ More Difficult ☐ Much More Difficult

2. With respect to spray quality:
☐ Much Worse ☐ Worse ☐ Same
☐ Better ☐ Much Better

3. With respect to application rate:
☐ Much Slower ☐ Slower ☐ Same
☐ Quicker ☐ Much Quicker

4. With respect to wet film quality (i.e. orange peel, pinholes, sags, etc.):
☐ Much Worse ☐ Worse ☐ Same
☐ Better ☐ Much Better

Additional comments:

What is your general opinion of this material compared to WBCC?

☐ Much Worse ☐ Worse ☐ Same
☐ Better ☐ Much Better

Please use back of form to provide any additional comments about the material.

Solvent Based CARC

How would you describe the mixing of this material when compared to solvent based CARC?

1. With respect to complexity of mix ratio:
☐ Much Easier ☐ Easier ☐ Same
☑ More Difficult ☐ Much More Difficult

2. With respect to mixing:
☐ Much Easier ☐ Easier ☐ Same
☑ More Difficult ☐ Much More Difficult

3. With respect to time:
☐ Much Slower ☑ Slower ☐ Same
☐ Quicker ☐ Much Quicker

Additional comments:

How would you describe the spray characteristics of this material when compared to solvent based CARC?

1. With respect to spraying:
☐ Much Easier ☑ Easier ☐ Same
☐ More Difficult ☐ Much More Difficult

2. With respect to spray quality:
☐ Much Worse ☐ Worse ☐ Same
☑ Better ☐ Much Better

3. With respect to application rate:
☐ Much Slower ☐ Slower ☐ Same
☑ Quicker ☐ Much Quicker

4. With respect to wet film quality (i.e. orange peel, pinholes, sags, etc.):
☐ Much Worse ☐ Worse ☑ Same
☐ Better ☐ Much Better

Additional comments:

What is your general opinion of this material compared to solvent based CARC?

☐ Much Worse ☐ Worse ☐ Same
☑ Better ☐ Much Better

Please use back of form to provide any additional comments about the material.

Bldg 1A Paint Shop — Bill Lang

MIL-P-64159 TYPE II WRCARC FIELD TRIAL APPLICATION SURVEY

Fill out the correct column, based on which coating is currently used

WBCC

How would you describe the mixing of this material when compared to WBCC?

1. With respect to complexity of mix ratio:
☐ Much Easier ☐ Easier ☐ Same
☐ More Difficult ☐ Much More Difficult

2. With respect to mixing:
☐ Much Easier ☐ Easier ☐ Same
☐ More Difficult ☐ Much More Difficult

3. With respect to time:
☐ Much Slower ☐ Slower ☐ Same
☐ Quicker ☐ Much Quicker

Additional comments:

How would you describe the spray characteristics of this material when compared to WBCC?

1. With respect to spraying:
☐ Much Easier ☐ Easier ☐ Same
☐ More Difficult ☐ Much More Difficult

2. With respect to spray quality:
☐ Much Worse ☐ Worse ☐ Same
☐ Better ☐ Much Better

3. With respect to application rate:
☐ Much Slower ☐ Slower ☐ Same
☐ Quicker ☐ Much Quicker

4. With respect to wet film quality (i.e. orange peel, pinholes, sags, etc.):
☐ Much Worse ☐ Worse ☐ Same
☐ Better ☐ Much Better

Additional comments:

What is your general opinion of this material compared to WBCC?

☐ Much Worse ☐ Worse ☐ Same
☐ Better ☐ Much Better

Please use back of form to provide any additional comments about the material.

Solvent Based CARC

How would you describe the mixing of this material when compared to solvent based CARC?

1. With respect to complexity of mix ratio:
☐ Much Easier ☐ Easier ☐ Same
☒ More Difficult ☐ Much More Difficult

2. With respect to mixing:
☐ Much Easier ☐ Easier ☐ Same
☒ More Difficult ☐ Much More Difficult

3. With respect to time:
☒ Much Slower ☐ Slower ☐ Same
☐ Quicker ☐ Much Quicker

Additional comments:

How would you describe the spray characteristics of this material when compared to solvent based CARC?

1. With respect to spraying:
☒ Much Easier ☐ Easier ☐ Same
☐ More Difficult ☐ Much More Difficult

2. With respect to spray quality:
☐ Much Worse ☐ Worse ☐ Same
☐ Better ☒ Much Better

3. With respect to application rate:
☐ Much Slower ☐ Slower ☐ Same
☒ Quicker ☐ Much Quicker

4. With respect to wet film quality (i.e. orange peel, pinholes, sags, etc.):
☐ Much Worse ☐ Worse ☒ Same
☐ Better ☐ Much Better

Additional comments:

What is your general opinion of this material compared to solvent based CARC?

☐ Much Worse ☐ Worse ☐ Same
☒ Better ☐ Much Better

Please use back of form to provide any additional comments about the material.

MIL-P-64159 TYPE II WRCARC FIELD TRIAL APPLICATION SURVEY

Fill out the correct column, based on which coating is currently used

ROBERT KONAN

WBCC

How would you describe the mixing of this material when compared to WBCC?

1. With respect to complexity of mix ratio:
Much Easier | Easier | Same
More Difficult | Much More Difficult

2. With respect to mixing:
Much Easier | Easier | Same
More Difficult | Much More Difficult

3. With respect to time:
Much Slower | Slower | Same
Quicker | Much Quicker

Additional comments:

How would you describe the spray characteristics of this material when compared to WBCC?

1. With respect to spraying:
Much Easier | Easier | Same
More Difficult | Much More Difficult

2. With respect to spray quality:
Much Worse | Worse | Same
Better | Much Better

3. With respect to application rate:
Much Slower | Slower | Same
Quicker | Much Quicker

4. With respect to wet film quality (i.e. orange peel, pinholes, sags, etc.):
Much Worse | Worse | Same
Better | Much Better

Additional comments:

What is your general opinion of this material compared to WBCC?

Much Worse | Worse | Same
Better | Much Better

Please use back of form to provide any additional comments about the material.

Solvent Based CARC

How would you describe the mixing of this material when compared to solvent based CARC?

1. With respect to complexity of mix ratio:
Much Easier | ✓ Easier | Same
More Difficult | Much More Difficult

2. With respect to mixing:
✓ Much Easier | Easier | Same
More Difficult | Much More Difficult

3. With respect to time:
Much Slower | Slower | Same
✓ Quicker | Much Quicker

Additional comments:

How would you describe the spray characteristics of this material when compared to solvent based CARC?

1. With respect to spraying:
Much Easier | ✓ Easier | Same
More Difficult | Much More Difficult

2. With respect to spray quality:
Much Worse | Worse | Same
Better | ✓ Much Better

3. With respect to application rate:
Much Slower | Slower | Same
Quicker | ✓ Much Quicker

4. With respect to wet film quality (i.e. orange peel, pinholes, sags, etc.):
Much Worse | Worse | Same
Better | ✓ Much Better

Additional comments:

What is your general opinion of this material compared to solvent based CARC?

Much Worse | Worse | Same
Better | ✓ Much Better

Please use back of form to provide any additional comments about the material.

INTENTIONALLY LEFT BLANK.

Appendix D. Vendor Certification Technical Data Sheet and Material Safety Data Sheet

This appendix appears in its original form, without editorial change.

Verification Form for Application of Coating System for Tobyhanna Army Deopt ESTCP Trial

I, Mark Whytsz, representing Sherwin Williams verify that the following paint system:

MIL-P-64159, TY II (Water-bourne Polyurethne CARC)

was applied according to proper painting practices and within manufacturer's suggested guidelines. Preparation of the steel substrate and topcoated surface of intermediate and primer coats were also satisfactory and within manufacturer's suggested guidelines.

Comments:

[signature]
Signature

10/31/00
Date

WATERBORNE CARC
MIL-C-64159 (proposed), Type 2 (Non-Siliceous)
POLYURETHANE CAMOUFLAGE COATING
GREEN 383, 34094
F93G502 COMPONENT A / V93V502 COMPONENT B

PRODUCT DESCRIPTION

F93G502 is a two component camouflage top coat. The components when properly mixed and reduced with deionized water may be spray-applied to properly prepared surfaces.

This coating meets the performance properties of MIL-C-46168D and MIL-C-53039A.

This product is on test at the US Army Research Lab in Aberdeen Proving Ground, MD for inclusion on the Experimental Products Program for non-siliceous waterborne CARC.

MATERIAL CONSTANTS

Color: Green 383
Fed. Std. 595B # 34094
Admix ratio by volume: 2:1:0.75
F93G502/V93V502/deionized water

Component A (F93G502)
Non volatiles, weight: 50.0 ± 2.0%
Non volatiles, volume: 35.0 ± 1.0%
VOC: 130g/l or 1.1#/gal minus water

Component B (V93V502)
Non volatiles, weight 75.0%+/-1.0%
Non volatiles, volume 69.3%+/-1.0%
VOC: 266/l or 2.2#/gal

Admixed Constants:
VOC: 1.50 lb./gallon or 180 g/l max.
Volume solids:36% admixed 2:1:0.75
Viscosity: 13-18 sec #3 Zahn (admixed 2:1:0.75)

THEORETICAL COVERAGE

577 sq.ft./gallon @ 1.0 mil dry no application loss
Gloss: 1.0 max. 60°
3.5 max. 85°
Gloss at 2.0 mils dry, spray.

HMIS Codes: H 2 F 1 R 0 PP 1
Flash Point degrees F >200°
Pot Life: 4 hours

CURE DATA

This product's cure depends on temperature and humidity. Cure rate at 70° F and 50% R.H.

Set to touch	60 minutes
Dry hard:	6 hours
Dry through:	8 hours

SUBSTRATE PREPARATION

Substrate should be clean, free of grease, dirt, rust or other contaminants that may cause adhesion problems. Recommended primer is MIL-P-53022. Allow primer to dry 2 hours. Then apply top coat. Follow surface cleaning and priming As described in MIL-C-53072B.

APPLICATION / REDUCTION

Component A should be shaken 5 minutes on Red Devil type shaker before opening. Mix Component B into Component A using a mechanical mixer. Mix for 3 minutes. The viscosity of the admixed components will increase significantly.Reduce to spray viscosity by adding deionized water. Mix by volume, 2 parts A, 1 part B, and 0.75 parts deionized water.

APPLICATION EQUIPMENT

Conventional Spray:
Use 45-60 pounds atomization air with a .070 fluid tip.

HVLP:
Use 65 pounds atomizing air (10 at cap) 5-10 pounds fluid with a .070" fluid tip.

Air Assisted Airless:
Not recommended due to the coarse nature of the pigmentation.

CLEAN UP INSTRUCTIONS

Flush line with clean water. Then use MIL-T-81772, Type 1 thinner for final equipment and line wash.

SPECIAL INSTRUCTIONS

Disposal:

Do not dispose of in sealed drums.

"Disposal" caution - This Waterborne polyurethane should not be disposed of in a sealed container due to carbon dioxide generation. Allow unused material to cure in a vented container and dispose of according to state, federal or local regulations for hazardous material.

NOTE:

"Product Data Sheets are periodically updated to reflect new information relating to the product. It is important that the customer obtain the most recent Product Data Sheet for the product being used. The information, rating and opinions stated above pertain to the material currently offered and represent the results of tests believed to be reliable. However, due to variations in customer handling and methods of application which are not know or under our control, The Sherwin-Williams Company cannot make any warranties or guarantees as to the end results."

Chicago: AWSTC/MW 6/21/00

MATERIAL SAFETY DATA SHEET

F93G00502
01 00X

MANUFACTURER'S NAME
THE SHERWIN-WILLIAMS COMPANY
101 Prospect Avenue N.W.
Cleveland, OH 44115

EMERGENCY TELEPHONE NO.
(216) 566-2917

DATE OF PREPARATION
12-APR-00

INFORMATION TELEPHONE NO.
(216) 566-2902

Section I -- PRODUCT IDENTIFICATION

PRODUCT NUMBER

F93G00502

HMIS CODES	
Health	2*
Flammability	0
Reactivity	0

PRODUCT NAME
WB CARC GN 383#34094,T II
PRODUCT CLASS
-

Section II -- HAZARDOUS INGREDIENTS

INGREDIENT CAS No.	% by WT	ACGIH TLV	OSHA PEL	UNITS	V.P.
1-Methyl-2-Pyrrolidone 872-50-4	3	Not Established			1.00
Chromium Oxide 1308-38-9	8	0.5	0.5	MG/M3	0.00
Cobalt-Chrome Oxide. 68187-49-5	14	0.5	0.5	MG/M3	0.00
Chromium III (as Cr)	9.29	0.50		MG/M3	

Section III -- PHYSICAL DATA

PRODUCT WEIGHT	11.02 lb/gal	1320 g/l
SPECIFIC GRAVITY	1.33	
BOILING POINT	212 - 396 F	100 - 202 C
MELTING POINT	Not Available	
VOLATILE VOLUME	65 %	
EVAPORATION RATE	Slower than ether	
VAPOR DENSITY	Heavier than air	
SOLUBILITY IN WATER	N.A.	

VOLATILE ORGANIC COMPOUNDS (VOC Theoretical)
1.08 lb/gal 130 g/l Less Federally Exempt Solvents
0.43 lb/gal 52 g/l Emitted VOC

Section IV -- FIRE AND EXPLOSION HAZARD DATA

FLASH POINT
>200 F PMCC

LEL	UEL
N.A.	N.A.

FLAMMABILITY CLASSIFICATION
Not Applicable

Continued on page 2

EXTINGUISHING MEDIA
Carbon Dioxide, Dry Chemical, Alcohol Foam
UNUSUAL FIRE AND EXPLOSION HAZARDS
Closed containers may explode (due to the build-up of pressure) when exposed to extreme heat.
SPECIAL FIRE FIGHTING PROCEDURES
Full protective equipment including self-contained breathing apparatus should be used. Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible autoignition or explosion when exposed to extreme heat.

Section V -- HEALTH HAZARD DATA

ROUTES OF EXPOSURE
Exposure may be by INHALATION and/or SKIN or EYE contact, depending on conditions of use. To minimize exposure, follow recommendations for proper use, ventilation, and personal protective equipment.
ACUTE Health Hazards
EFFECTS OF OVEREXPOSURE
Irritation of eyes, skin and upper respiratory system. In a confined area vapors in high concentration may cause headache, nausea or dizziness.
SIGNS AND SYMPTOMS OF OVEREXPOSURE
Redness and itching or burning sensation may indicate eye or excessive skin exposure.
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
None generally recognized.
EMERGENCY AND FIRST AID PROCEDURES

If INHALED:	If affected, remove from exposure. Restore breathing. Keep warm and quiet.
If on SKIN:	Wash affected area thoroughly with soap and water. Remove contaminated clothing and launder before re-use.
If in EYES:	Flush eyes with large amounts of water for 15 minutes. Get medical attention.
If SWALLOWED:	Get medical attention.

CHRONIC Health Hazards
Cobalt and cobalt compounds are classified by IARC as possibly carcinogenic to humans (group 2B) based on experimental animal data, however, there is inadequate evidence in humans for its carcinogenicity.
Chromium III is considered the active species in cancer induction, but Chromium III compounds do not cross the cell wall. However, there is some evidence that Chromium III compounds of respirable particle size may be taken up by the cells in the lung.

Section VI -- REACTIVITY DATA

STABILITY -- Stable
CONDITIONS TO AVOID
None known.
INCOMPATIBILITY
None known.
HAZARDOUS DECOMPOSITION PRODUCTS
By fire: Carbon Dioxide, Carbon Monoxide, Oxides of Nitrogen, possibility of Hydrogen Cyanide, Oxides of Metals in Section II
HAZARDOUS POLYMERIZATION
Will not occur

Continued on page 3

Section VII -- SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Remove all sources of ignition. Ventilate and remove with inert absorbent.
WASTE DISPOSAL METHOD
Waste from this product may be hazardous as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261.
Waste must be tested for extractability to determine the applicable EPA hazardous waste numbers.
Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State, and Local regulations regarding pollution.

Section VIII -- PROTECTION INFORMATION

PRECAUTIONS TO BE TAKEN IN USE
Use only with adequate ventilation. Avoid breathing vapor and spray mist. Avoid contact with skin and eyes. Wash hands after using.
This coating may contain materials classified as nuisance particulates (listed "as Dust" in Section II) which may be present at hazardous levels only during sanding or abrading of the dried film. If no specific dusts are listed in Section II, the applicable limits for nuisance dusts are ACGIH TLV 10 mg./m3 (total dust), 3 mg./m3 (respirable fraction), OSHA PEL 15 mg./m3 (total dust), 5 mg./m3 (respirable fraction).
VENTILATION
Local exhaust preferable. General exhaust acceptable if the exposure to materials in Section II is maintained below applicable exposure limits. Refer to OSHA Standards 1910.94, 1910.107, 1910.108.
RESPIRATORY PROTECTION
If personal exposure cannot be controlled below applicable limits by ventilation, wear a properly fitted organic vapor/particulate respirator approved by NIOSH/MSHA for protection against materials in Section II.
When sanding, wirebrushing, abrading, burning or welding the dried film, wear a particulate respirator approved by NIOSH/MSHA for protection against non-volatile materials in Section II.
PROTECTIVE GLOVES
Wear gloves which are recommended by glove supplier for protection against materials in Section II.
EYE PROTECTION
Wear safety spectacles with unperforated sideshields.

Section IX -- PRECAUTIONS

DOL STORAGE CATEGORY
3B
PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Keep container closed when not in use. Transfer only to approved containers with complete and appropriate labeling. Do not take internally. Keep out of the reach of children.

Section X -- OTHER REGULATORY INFORMATION

SARA 313 (40 CFR 372.65C) SUPPLIER NOTIFICATION

CAS No.	CHEMICAL/COMPOUND	% by WT	% Element
872-50-4	1-Methyl-2-Pyrrolidone	3	
	Chromium Compound.	21	9.3

Continued on page 4

Cobalt Compound.	14	1.6
Zinc Compound.	14	1.9

CALIFORNIA PROPOSITION 65
WARNING: This product contains chemicals known to the State of California to cause cancer.

TSCA CERTIFICATION
All chemicals in this product are listed, or are exempt from listing, on the TSCA Inventory.

The above information pertains to this product as currently formulated, and is based on the information available at this time. Addition of reducers or other additives to this product may substantially alter the composition and hazards of the product. Since conditions of use are outside our control, we make no warranties, express or implied, and assume no liability in connection with any use of this information.

MATERIAL SAFETY DATA SHEET

V93V00502
01 00

MANUFACTURER'S NAME
THE SHERWIN-WILLIAMS COMPANY
101 Prospect Avenue N.W.
Cleveland, OH 44115

EMERGENCY TELEPHONE NO.
(216) 566-2917

DATE OF PREPARATION
13-APR-00

INFORMATION TELEPHONE NO.
(216) 566-2902

Section I -- PRODUCT IDENTIFICATION

PRODUCT NUMBER

V93V00502

HMIS CODES	
Health	3*
Flammability	2
Reactivity	1

PRODUCT NAME
WATERBORNE CARC CATALYST
PRODUCT CLASS
-

Section II -- HAZARDOUS INGREDIENTS

INGREDIENT CAS No.	% by WT	ACGIH TLV	OSHA PEL	UNITS	V.P.
Oxo-Hexyl Acetate. 88230-35-7	25	Not Established			0.70
Hexamethylene Diisocyanate (max.) 822-06-0	0.2	0.005		PPM	0.05
Hexamethylene Diisocyanate Polymer 28182-81-2	75	Not Established			0.00

Section III -- PHYSICAL DATA

PRODUCT WEIGHT	8.87 lb/gal	1063 g/l
SPECIFIC GRAVITY	1.07	
BOILING POINT	327 - 349 F	163 - 176 C
MELTING POINT	Not Available	
VOLATILE VOLUME	30 %	
EVAPORATION RATE	Slower than ether	
VAPOR DENSITY	Heavier than air	
SOLUBILITY IN WATER	N.A.	

VOLATILE ORGANIC COMPOUNDS (VOC Theoretical)
2.21 lb/gal 265 g/l Less Federally Exempt Solvents
2.21 lb/gal 265 g/l Emitted VOC

Section IV -- FIRE AND EXPLOSION HAZARD DATA

FLASH POINT	LEL	UEL
138 F PMCC	1.0	8.0

FLAMMABILITY CLASSIFICATION
Combustible, Flash above 99 and below 200 F
EXTINGUISHING MEDIA
Carbon Dioxide, Dry Chemical, Foam

Continued on page 2

UNUSUAL FIRE AND EXPLOSION HAZARDS

Keep containers tightly closed. Isolate from heat, electrical equipment, sparks, and open flame. Closed containers may explode when exposed to extreme heat. Application to hot surfaces requires special precautions. During emergency conditions overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.

SPECIAL FIRE FIGHTING PROCEDURES

Full protective equipment including self-contained breathing apparatus should be used. Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible autoignition or explosion when exposed to extreme heat.

Section V -- HEALTH HAZARD DATA

ROUTES OF EXPOSURE

Exposure may be by INHALATION and/or SKIN or EYE contact, depending on conditions of use. To minimize exposure, follow recommendations for proper use, ventilation, and personal protective equipment.

ACUTE Health Hazards

EFFECTS OF OVEREXPOSURE

Irritation of eyes, skin and respiratory system. May cause nervous system depression. Extreme overexposure may result in unconsciousness and possibly death.

SIGNS AND SYMPTOMS OF OVEREXPOSURE

Headache, dizziness, nausea, and loss of coordination are indications of excessive exposure to vapors or spray mists.

Redness and itching or burning sensation may indicate eye or excessive skin exposure.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE

None generally recognized.

EMERGENCY AND FIRST AID PROCEDURES

If INHALED:	If affected, remove from exposure. Restore breathing. Keep warm and quiet.
If on SKIN:	Wash affected area thoroughly with soap and water. Remove contaminated clothing and launder before re-use.
If in EYES:	Flush eyes with large amounts of water for 15 minutes. Get medical attention.
If SWALLOWED:	Get medical attention.

CHRONIC Health Hazards

No ingredient in this product is an IARC, NTP or OSHA listed carcinogen.

Reports have associated repeated and prolonged overexposure to solvents with permanent brain and nervous system damage.

Section VI -- REACTIVITY DATA

STABILITY -- Stable

CONDITIONS TO AVOID

None known.

INCOMPATIBILITY

None known.

HAZARDOUS DECOMPOSITION PRODUCTS

By fire: Carbon Dioxide, Carbon Monoxide

HAZARDOUS POLYMERIZATION

Will not occur

Continued on page 3

Section VII -- SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Remove all sources of ignition. Ventilate and remove with inert absorbent.
WASTE DISPOSAL METHOD
Waste from this product may be hazardous as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261.
Waste must be tested for ignitability to determine the applicable EPA hazardous waste numbers.
Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State, and Local regulations regarding pollution.

Section VIII -- PROTECTION INFORMATION

PRECAUTIONS TO BE TAKEN IN USE
Use only with adequate ventilation. Avoid breathing vapor and spray mist. Avoid contact with skin and eyes. Wash hands after using.
This coating may contain materials classified as nuisance particulates (listed "as Dust" in Section II) which may be present at hazardous levels only during sanding or abrading of the dried film. If no specific dusts are listed in Section II, the applicable limits for nuisance dusts are ACGIH TLV 10 mg./m3 (total dust), 3 mg./m3 (respirable fraction), OSHA PEL 15 mg./m3 (total dust), 5 mg./m3 (respirable fraction).
VENTILATION
Local exhaust preferable. General exhaust acceptable if the exposure to materials in Section II is maintained below applicable exposure limits. Refer to OSHA Standards 1910.94, 1910.107, 1910.108.
RESPIRATORY PROTECTION
If personal exposure cannot be controlled below applicable limits by ventilation, wear a properly fitted organic vapor/particulate respirator approved by NIOSH/MSHA for protection against materials in Section II.
When sanding or abrading the dried film, wear a dust/mist respirator approved by NIOSH/MSHA for dust which may be generated from this product, underlying paint, or the abrasive.
PROTECTIVE GLOVES
Wear gloves which are recommended by glove supplier for protection against materials in Section II.
EYE PROTECTION
Wear safety spectacles with unperforated sideshields.

Section IX -- PRECAUTIONS

DOL STORAGE CATEGORY
2
PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Contents are COMBUSTIBLE. Keep away from heat and open flame.
Consult NFPA Code. Use approved Bonding and Grounding procedures.
Keep container closed when not in use. Transfer only to approved containers with complete and appropriate labeling. Do not take internally. Keep out of the reach of children.
OTHER PRECAUTIONS
Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal.